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(71) Applicant *(for all designated States except US)*: LINX PRINTING TECHNOLOGIES PLC [GB/GB]; Burrel Road, St. Ives, Huntingdon, Cambridgeshire PE17 4LE (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: GERRARD, Jeffrey [GB/GB]; 51 Prospero Way, Huntingdon, Cambridgeshire PE18 7PQ (GB).

(74) Agents: BERESFORD, Keith, Denis, Lewis et al.; Beresford & Co., 2-5 Warwick Court, High Holborn, London WC1R 5DJ (GB).

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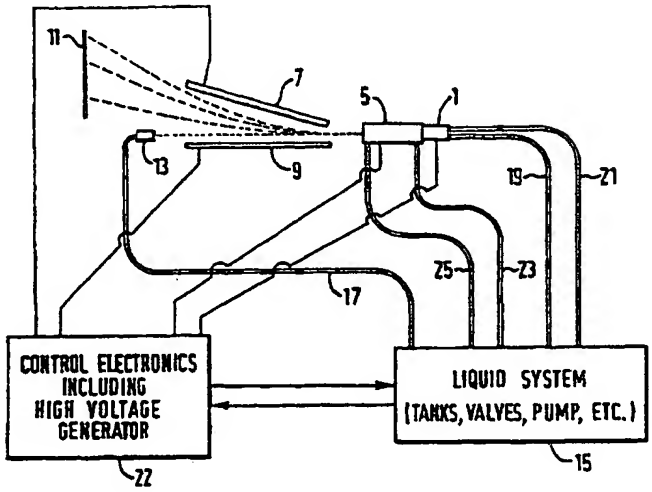

(57) Abstract

In an ink jet printer of the type in which ink drops are charged by a charge electrode (59) and then deflected by deflection electrodes (7, 9), a charge assembly (5) is provided which encloses the ink jet path at the position of the charge electrode and preferably over the length of the ink path from the charge electrode to the ink gun (1). The charge assembly (5) is provided with lines (23, 25) for providing flushing liquid into the enclosed part of the ink path and sucking it out again, so as to clean the enclosing surface. This allows an automated flushing operation to replace the manual cleaning of the charge electrode which is necessary in a typical design in which the ink path is not enclosed. The flushing operation can be fully automated, minimising the need for manual cleaning. The charge assembly (5) can be provided by a body (51) which encloses the end cap (47) of the ink gun (1) and has a bore to provide the enclosure (53) around the path of the ink jet (3). An enlarged diameter part of the bore enables insertion of a metal tube to form the charge electrode (59).

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INK JET PRINTER

The present invention relates to ink jet printers of the type in which an ink jet, issuing from an ink gun, breaks into ink drops while under the electrical influence of a charge electrode so that electric charge is captured on the ink drops according to the signal on the charge electrode, and a deflection electrode arrangement creates an electric field for deflecting ink drops owing to the captured charge on the drops. General background information about such ink jet printers can be found, for example, in WO89/03768 and US patent 5455614.

In this type of ink jet printer, normally the ink jet runs continuously during a period when printing is desired, and any drops which are not required for printing are directed to a gutter which collects them, and typically recycles the ink back to an ink tank supplying the ink gun. Typically the extent of deflection is varied by varying the voltage applied to the charge electrode, so as to vary the amount of charge captured on the drops, and the gutter is positioned to catch drops which are not charged. Typically, such printers are arranged to print on articles which are conveyed past the printer on a conveyor belt or other conveying apparatus. The articles may be pots, bottles, cans or other containers for foodstuffs or other grocery items, foodstuffs such as eggs, pharmaceutical pills and

capsules, electrical components, packaging and other industrial and commercial articles. The printers may be used for printing logos, manufacturing or sell-by dates, batch numbers, bar codes, or any other information or patterns which it is desired should be printed on such articles. Printers of this type are not normally used for printing output text from data processing apparatus such as word processors.

In ink jet printers of this type, various arrangements are known for cleaning the inside of the ink gun, e.g. by flushing, and also for cleaning the outside of the surface through which the ink jet leaves the gun. An ink gun flushing system is disclosed, for example, in EP-A-0424008 and US 5126752. Such arrangements help to prevent and correct total or partial blockages of the ink gun due to solid particles in the ink or ink encrustations in the gun, which may block the ink jet or cause it to misfire.

WO94/16900 discloses an arrangement in which the face plate of the ink gun, in which the jet-forming orifice is formed, contains passages within the plane of the plate which open into an enlarged bore surrounding the jet-forming orifice. This arrangement is used to cause a cleaning fluid flow in through one passage, across the enlarged bore and out through the other passage in order to clean any build-up of dried ink at the jet-forming orifice.

In ink jet printers of the present type, some components (and particularly the charge electrode) must be positioned very close to the ink jet, for example with a spacing of less than 1 mm. If the jet misfires (i.e. it does not leave the gun cleanly in the correct direction) or the ink momentarily does not travel precisely along the correct ink path when the ink jet is being started or stopped, the ink tends to spray onto such components. Accordingly, such components tend to become encrusted with ink during prolonged use of an ink jet printer. This can interfere with the correct working of the components. Additionally, because of the very small spacing between components such as a charge electrode and the ink jet, the encrustation can build up to a point where it interferes with ink on the correct ink path. Accordingly, the charge electrode has to be cleaned from time to time. Normally this is done manually, by squirting a cleaning or flushing liquid onto the charge electrode, and sometimes additionally by subsequent gentle brushing. Ink jet printer inks are normally diluted in use with a solvent (methyl ethyl ketone is often used), and for convenience the solvent is normally used as the flushing or cleaning liquid.

WO86/06025 discloses a continuous ink jet printing apparatus having a charge electrode in the form of a plate located close to the jet-forming orifice. In this system, printing takes place with uncharged (and

therefore undeflected) ink drops whereas drops which are not to be printed are deflected into a gutter or catcher. The charge plate and the catcher are provided very close to each other on one side of the ink path and a wall is provided on the other side of the ink path. A cleaning device can be pressed against the downstream ends of the gutter and the wall to take part in a head cleaning operation, in which ink is forced through the jet-forming orifice in a non-stable condition spraying in all directions and impacting the surfaces of the charge plate and the gutter in order to clean dirt and re-dissolve any ink. Ink is then held by capillary action between the wall on one side and the charge electrode and the gutter on the other side, while ultrasonic energy is provided for cleaning. A pressurised air flow may also be driven through the space between the charge electrode and the gutter on one side and the wall on the other side, to remove ink remaining in this space.

JP-A-4-53753 proposes an arrangement in which a rectangular parallelopiped casing is provided around the jet-forming orifice, the charge electrode, the deflection electrode and the gutter. Within the casing, supply ports are provided above each of the jet-forming orifice, the charge electrode, the deflection electrode and the gutter for supplying a washing liquid. The casing has a hole at its end to allow the ink jet to leave, a hole at the top through which compressed air is introduced,

and a hole at the bottom for the discharge of washing liquid.

IBM Technical Disclosure Bulletin Vol. 23 No. 1 (June 1980) at pages 93 to 95 proposes a system for selectively introducing a rinse fluid and/or applying a vacuum to various areas of an ink jet head assembly. Respective lines are connected to each of a gutter, a lower deflection plate connected to the gutter, an upper deflection plate which forms with the lower deflection plate a tunnel for the ink jet, a charge electrode positioned above the path of the ink jet and a charge electrode gutter. A rinse fluid supply and a vacuum source are also provided, and each line has a respective valve through which it can be connected selectively either to the rinse fluid supply or the vacuum source. To clean the entire assembly, a door can be moved to contact the gutter and close off the tunnel between the deflection electrodes, and another door placed to close off the gap between the charge electrode gutter and the lower deflection plate. All the valves could then be positioned to flood the area and then switched to vacuum to evacuate the rinse fluid. In an alternative arrangement, only two valves are used. The first valve is connected to the lines for the charge electrode and the charge electrode gutter. In a first position it connects both of these to the vacuum source. In a second position it connects the charge electrode to the rinse

fluid supply and the charge electrode gutter to the vacuum source so that rinse fluid flows from the charge electrode across the face of the ink gun and is removed by the charge electrode gutter. The second valve controls the lines for the two deflection electrodes and the main gutter. In one position it connects all of these to the vacuum source. In the other position, used when the door at the end of the deflection electrodes is closed against the gutter, it connects the upper and lower deflection electrodes to the rinse fluid supply while connecting the main gutter to the vacuum source, so that rinse fluid flows through screens in the deflection plates and this flow is taken up by the vacuum applied to the gutter. This arrangement cannot flood and evacuate the entire area of the assembly, but can rinse and evacuate portions of it.

According to one aspect of the present invention at least a part of the ink path in the vicinity of the charge electrode is enclosed, either by forming the charge electrode as a tube or by providing another enclosing member. Preferably this enclosure extends up to and encloses the orifice in the ink gun through which the ink jet emerges. The downstream end of the enclosure is open, and the upstream end either is open or encloses the orifice in the ink gun, so that during normal printing operation the ink jet from the orifice in the ink gun travels unhindered through and out of the

enclosure. If ink travelling in the enclosure deviates from the correct ink path, it will hit the side of the enclosure. The enclosure can be flooded with flushing liquid in order to clean it, which can make the cleaning process easier. Additionally, the enclosure is provided with a conduit for supplying flushing liquid to it and a conduit for applying suction to it in order to facilitate the cleaning process. If these conduits are connected respectively to a flushing liquid supply and a suction source, it is possible to arrange for the ink jet printer to perform flushing operations automatically to clean the enclosure, thereby reducing the need for manual intervention to clean components of the printer downstream of the ink gun. The enclosed space has a narrow diameter between the conduit for applying suction and the open end, so that the suction prevents any flushing liquid from dribbling out of the open end. Some configurations of such an enclosure also provide other advantages, particularly when the enclosure encloses the orifice through which the jet leaves the ink gun.

In another aspect of present invention there is provided an arrangement for enclosing a charge electrode of an ink jet printer, to allow a flushing liquid to be provided to the enclosed volume and caused to flow through it.

In another aspect of the present invention there is provided an assembly comprising a charge electrode and

an enclosure means enclosing a portion of the path of the ink jet at the location of the charge electrode.

It is an another aspect of the present invention to provide an assembly, comprising a charge electrode and enclosure means enclosing a portion of the path of the ink jet at the location of the charge electrode, in which the enclosure means comprises fittings, such as stub tubes, recesses or any other convenient arrangement, for allowing connection of liquid supply means and suction means to the enclosure means so that liquid from a liquid supply means coupled to the enclosure means by a fitting can flow into the enclosed volume, and suction means coupled to the enclosure means by a fitting can remove liquid from the enclosed volume.

In a preferred embodiment, there is a provided an ink jet printer having:

an ink gun for ejecting an ink jet along an ink path from a jet-forming orifice;

a charge electrode downstream of the jet-forming orifice, for controlling the electric potential in a part of the ink path in which the ink drops separate from the ink jet, thereby to charge the ink drops; and

a deflection electrode arrangement downstream of the charge electrode, for creating an electric field for deflecting the charged ink drops,

characterised by

a first conduit, at or downstream of the jet forming

orifice and at or upstream of the charge electrode, a second conduit, downstream of the first conduit and at or downstream of the charge electrode, and means forming an enclosure around the ink path at least from the first conduit to the second conduit, the first and second conduits opening into the enclosure whereby a cleaning liquid can flow along the conduits and the enclosed part of the ink path between the conduits.

In the case where conduits are provided for supplying flushing liquid and suction to the enclosure, preferably a conduit is provided as close as possible to each end of the enclosure, so that the flushing operation is enabled to clean the entire length of the enclosure. If the enclosure also encloses the orifice in the ink gun through which the ink jet leaves, it is preferred that one of the conduits, (preferably for supply of flushing liquid) opens into the enclosure at the orifice in the ink gun. For example, the surface of the ink gun adjacent the orifice can be used to provide part of the side wall of the conduit for the last part of the conduit before it opens into the enclosure. This arrangement improves the effectiveness of cleaning of the orifice in the ink gun.

In the case where the enclosure encloses the orifice in the ink gun through which the jet leaves, so that the end of the enclosure towards the ink gun is closed by a surface of the ink gun and only the other end of the

enclosure is open to the surroundings, it is preferred that the flushing operation is conducted by providing flushing liquid through a conduit opening into the enclosure at or near its upstream end (i.e. its end towards the ink gun) while suction is applied to a conduit opening into the enclosure close to its downstream end (i.e. is open end remote from the ink gun). This means that while the flushing liquid is flooding the enclosure and flowing through it, it is at its highest pressure at the end of the enclosure which is closed by the ink gun and it at a low pressure under the influence of the suction conduit when it is close to the open end of the enclosure, thereby avoiding undesired outflow of the flushing liquid through the open end of the enclosure. Preferably the suction conduit tends to suck air in through the open end of the enclosure, thereby ensuring that no flushing liquid flows out. With this arrangement, it is preferred that this flushing flow is followed by applying suction to the upstream conduit close to the ink gun, so as to suck the entire length of the enclosure clear of flushing liquid.

In order to avoid the outflow of the flushing liquid through the open end of the enclosure, the diameter of the enclosed space is limited to 2 mm at the point where the suction conduit opens into it, at the open end of the enclosure, or at at least some point therebetween. The minimum diameter must be sufficiently large for the ink

jet to pass through it, but it has been found in practice that if the minimum diameter is too large it is very difficult, if not impossible, to prevent flushing liquid from dribbling out of the open end of the enclosure even if very strong suction is applied to the suction conduit. The minimum diameter is preferably in the range of 1.0 to 1.2 mm, and in practice a diameter of about 1.1 mm is preferred. If the suction conduit opens into the enclosed space at two or more radial positions around the path of the ink jet but at substantially the same position along the path, and its position along the path is at or very close to a position with the minimum diameter, undesired outflow of the flushing liquid can be avoided with a larger minimum diameter than in the case where the suction conduit opens only at one side of the path of the ink jet. However, even in this case it is difficult to avoid such undesired outflow if the minimum diameter exceeds 2 mm.

If one end of the enclosure means encloses the orifice of the ink gun, this end of the enclosure means can be closed by the ink gun and this will prevent the flushing liquid from dribbling out. However, if the enclosure means does not enclose the orifice of the ink gun the upstream (with respect to the ink jet) end of the enclosure means must also be open, and so a suction conduit and a minimum diameter of no more than 2 mm should be provided at this end also.

Preferably the suction source provides a static suction which is at least 80 kPa below atmospheric pressure, and is preferably about 90 kPa below atmospheric pressure (atmospheric pressure is about 100 kPa).

In another aspect, the present invention provides an ink jet printer in which the ink path is enclosed in the immediate vicinity of the ink gun, the enclosure including the orifice in the ink gun through which the ink jet leaves, and the enclosure being provided with one or more conduits for the supply and removal of a liquid to the enclosure.

This arrangement permits a dummy starting operation to be carried out with the ink jet, in which the enclosure is flooded with the liquid prior to starting the ink jet, and then the ink jet is ejected briefly from the ink gun into the liquid flooding the enclosure. The liquid flooding the enclosure prevents the ink jet from continuing so that no ink reaches parts of the printer downstream (with respect to the ink jet) of the enclosure. This provides an operation for purging the interior of the ink gun of air which may be mixed with the ink during the initial moments of forming the ink jet, without creating an ink jet downstream of the enclosure. The ink jet is then stopped, the enclosure sucked clear of liquid and the jet re-started to begin normal operation.

During the initial moments of the dummy start, when the ink jet is fired into the liquid filled enclosure, there may be air inside the in gun. This tends to prevent the ink jet from starting cleanly and immediately travelling along the correct path, because the compressibility of the air means that the ink pressure at the orifice rises to normal jet forming pressure over a short period instead of rising instantaneously. The liquid in the enclosure blocks the ink jet during this period to prevent the jet from spraying ink onto other components during the brief moment when it is not formed properly. When the jet is restarted after the enclosure has been sucked clear, air has been purged from the ink gun enabling a more sudden pressure rise to form the jet at the orifice and therefore allowing a cleaner start of the jet on this occasion.

As is illustrated in the accompanying embodiments, the various aspects of the present invention are preferably combined.

Various other preferred and optional features are disclosed in connection with embodiments of the present invention which will now be described with reference to the accompanying drawings. Although some features are referred to only in the context of some particular embodiments and in combination with some particular other features, the preferred and optional forms of the present invention are not limited only to the illustrated

arrangements and combinations of features, but instead features from different embodiments may be combined and features shown in one embodiment may be used without the presence of other features from the same embodiment in a wide variety of arrangements as will be apparent to those skilled in the art.

In the accompanying drawings:

Figure 1 illustrates schematically an ink jet printer embodying the present invention;

Figure 2 shows the arrangement of valves in the liquid lines for the ink gun and the charge assembly of the printer of Figure 1;

Figure 3 is a drawing equivalent to Figure 1 for an alternative printer embodying the present invention;

Figure 4 is a drawing equivalent to Figure 2, for the printer of Figure 3;

Figure 5 is a section through an example of an ink gun;

Figure 6 is a sectional view showing the junction between the ink gun and the charge assembly in a printer according to Figures 3 and 4;

Figure 7 is a sectional view showing an alternative arrangement to Figure 6;

Figures 8 to 16 are sectional views through different constructions for the charge assembly.

Figure 1 illustrates schematically an ink jet printer embodying the present invention. An ink gun 1

provides an ink jet 3 which passes through a charge assembly 5 which incorporates a charge electrode. While in the charge assembly 5, and under the electric influence of the charge electrode, the ink jet 3 breaks into drops with the consequence that the amount of electric charge captured on each drop depends on the voltage applied to the charge electrode. The ink jet 3, now in drop form, continues from the charge assembly 5 to pass between two deflection electrodes 7, 9 which are maintained at substantially different potentials so as to provide a strong electric field between them. The charge on each ink drop interacts with the electric field to cause the ink drop to be deflected by an amount depending on the amount of charge. In this way, ink drops are deflected into various paths so as to strike a surface 11 at various positions so as to print the desired pattern on the surface 11. Uncharged drops pass between the deflection electrodes 7, 9 without being deflected, and are received by a gutter 13. The gutter 13 is connected to the liquid system 15 of the printer by a gutter line 17. The liquid system 15 applies suction to the gutter line 17 so that ink drops collected by the gutter 13 flow along the gutter line 17 to the liquid system 15, where they are delivered to an ink supply tank. Ink from the ink supply tank is conveyed under pressure to the ink gun 1 by a feed line 19 to provide the ink which forms the jet 3. The ink gun 1 is

also connected to the liquid system 15 by a purge line 21 to which suction can be applied by the liquid system 15 for purging the inside of the ink gun 1.

The operation of the printer is controlled by control electronics 22. The control electronics receives signals from sensors in the liquid system 15, such as an ink pressure sensor, and any other sensors which may be provided as desired. It sends control signals to the liquid system 15 to control components such as a pump or other means for pressuring the ink, and valves, and in this way the control electronics 22 monitors and controls the flow of ink and solvent within the printer, stopping, starting and switching flows as required. The control electronics 22 also provides a drive signal to the ink gun 1 for imparting controlled pressure variations to the ink jet in order to control the manner in which the jet breaks into drops, and provides the charging signal to the charge electrode. The control electronics 22 also includes a high voltage generator which generates the potential difference which is applied between the deflection electrodes 7, 9 to provide the electric field between them for deflecting charged ink drops. In this way, the control electronics 22 acts to control all the operations of the printer. It will also receive inputs from outside the printer such as user commands and timing signals from the conveying mechanism which conveys past the print head the articles to be printed on to (each

article providing in turn the surface 11).

The charge assembly 5 comprises a block with a hole through it to enable the ink jet 3 to pass, so that it forms an enclosure around a part of the ink jet 3. This enclosure is connected to the liquid system 15 by a flushing line 23 and a suction line 25. During an operation for cleaning the enclosure of the charge assembly 5 by flushing it, solvent from the liquid system 15 is provided along the flushing line 23 while suction is applied to the suction line 25, so that the solvent flows from the liquid system along the flushing line 23, along the enclosure, and then along the suction line 25 back to the liquid system. The returned solvent, mixed with any ink which may be flushed from the enclosure, is passed to the ink tank.

The solvent is arranged to flow along the flushing line at a very slow rate, preferably at about 1 to 10 ml per minute e.g. 6 ml per minute. A flushing operation conducted before starting the ink jet might take for example about 30 seconds and use about 1 ml of solvent. This slow flow rate minimises the amount of solvent which is used in the flushing operation, thereby minimising the extent to which solvent returned from flushing the charge assembly 5 dilutes the ink in the ink tank. Additionally, the slow flow rate means that the solvent is only slightly pressurised as it flows along the enclosure in the charge assembly 5, so that it flows

reliably to the suction line 25 rather than dribbling out of the open ends of the enclosure. The suction line 25 provides suction at about 90 kPa (static).

Figure 2 illustrates schematically the ink gun 1, the charge assembly 5, the feed line 19, the purge line 21, the flushing line 23 and the suction line 25 in the printer of Figure 1, together with valves from the liquid system 15 provided in those lines. The feed valve 27 in the feed line 19 serves to connect the ink gun 1 to the pressurised ink supply or to isolate the ink gun 1 from the pressurised ink supply. The purge valve 29 in the purge line 21 connects the ink gun 1 to the suction source or isolates the ink gun 1 from the suction source. The flushing valve 31 connects the flushing line 23 either to the flushing liquid supply or to the suction source, or isolates the flushing line 23 from both the flushing liquid supply and the suction source. The suction valve 33 serves to connect the suction line 25 to the suction source or to isolate the suction line 25 from the suction source.

In Figures 1 and 2 the charge assembly 5 is spaced from the ink gun 1. However, as an alternative construction the charge assembly 5 may extend to contact the ink gun 1 as shown in Figure 3 and 4, which are schematic drawings corresponding to Figures 1 and 2 for such an alternative construction. As will be explained later, some operational advantages can be obtained from

the arrangement of Figures 3 and 4 in which the charge assembly 5 contacts the ink gun 1.

The charge assembly 5 provides a means for cleaning the path of the ink jet in the region of the charge electrode, and in the arrangement of Figures 3 and 4 it also provides a means for cleaning the jet forming orifice in the ink gun 1. Additionally, in cases where the jet has not started properly and ink is fouling the inside of the charge assembly 5, the jet can be stopped, the ink can be sucked away, and the charge assembly can be flushed, leaving it ready for another attempt to start the jet. The cleaning operation can be automated using the control electronics 22. Conventional systems for detecting the presence of the ink jet can be used to detect the failure of the jet to start properly, and this can trigger the cleaning operation automatically, so that user intervention is not required.

During normal operation with the ink jet running, the purge valve 29, the flushing valve 31 and the suction valve 33 will all be closed so as to block flow through their respective lines, and only the feed valve 27 will be open, so as to provide pressurised ink to the ink gun 1. When the jet is not running and the printer is idle, the feed valve 27 will be closed so as to separate the ink supply from the ink gun 1, and the purge valve 29 will normally be closed.

Flushing the enclosure of the charge assembly 5 is

conducted when the ink jet is not running, so that in this case the feed valve 27 is closed. In order to begin flushing, the suction valve 33 is opened so as to connect the suction line 25 to the suction source, and the flushing valve 31 is positioned to connect the flushing liquid supply to the flushing line 23. If the charge assembly 5 contacts the ink gun 1 as shown in Figures 3 and 4, the purge valve 29 is also kept closed during this flushing operation so that suction from the purge valve is not transmitted through the ink gun 1 to the enclosure of the charge assembly 5. Under this condition, the flushing liquid will flow from the liquid system through the flushing valve 31 along the flushing line 23, through the enclosure in the charge assembly 5, and back along the suction line 25 and through the suction valve 33 to return to the ink system 15. This flushing flow fills the enclosure in the charge assembly 5 with flushing liquid. When the flushing is finished, it is necessary to remove the flushing liquid from the enclosure 5. To do this, the flushing valve 31 is operated to disconnect the flushing line 23 from the flushing liquid supply, and the suction valve 33 and the flushing valve 31 are operated so that suction is applied to at least one of the suction line 25 and the flushing line 23 in order to suck the remaining flushing liquid out of the enclosure in the charge assembly 5. The suction at this stage can be applied to both the suction line 25 and the flushing

line 23, either simultaneously or in alternation.

When the ink jet is running, it will tend to suck in any flushing liquid which has been left in flushing line 23 or the suction line 25 at the points where these lines open into the enclosure. Therefore the flushing liquid should be cleared from at least these parts of the lines. If suction is applied to both lines, this will tend to clear them. If suction is applied only to one line, air should be allowed into the other so that the liquid in it can be sucked out.

In the case where the charge assembly 5 contacts the ink gun 1 as shown in Figures 3 and 4, it is preferred that suction is applied at the end of the enclosure remote from the ink gun 1 during the flushing operation, so that the flushing liquid is at relatively low pressure under the influence of the suction line at the end of the enclosure open to the atmosphere and the higher pressure flushing liquid provided along the flushing line 23 enters the enclosure at the end where it is closed by the ink gun 1, so as to prevent the pressure of the flushing liquid from causing it to dribble out of the open end of the enclosure of the charge assembly 5. However, in this case it is preferred that the flushing liquid is sucked out of the enclosure in the charge assembly 5 at the end of the flushing operation by providing suction along the flushing line 23 to the end of the enclosure close to the ink gun 1 and not open to the atmosphere, while suction

is not provided simultaneously along the suction line 25 to the end of the enclosure open to the atmosphere. This ensures that the flushing liquid is reliably sucked out from the full length of the enclosure in the charge assembly 5.

In the case where the charge assembly 5 reaches the ink gun 1, so that the enclosure in the charge assembly 5 communicates with the jet forming orifice of the ink gun 1, additional flow patterns are possible. Two useful flow patterns, each of which can be used to clean the jet forming orifice, are the "reverse flow flush" and the "dummy start".

A reverse flow flush is carried out when the enclosure in the charge assembly 5 has been filled with flushing liquid by the normal flushing flow. At this point, the purge valve 29 is opened so as to connect the suction source to the inside of the ink gun 1 through the purge line 21. As a consequence, flushing liquid from the enclosure in the charge assembly 5 is sucked through the jet forming orifice into the ink gun, thereby flushing the orifice and tending to remove dust or encrusted in which may be obstructing it.

The dummy start is also carried out when the enclosure in the charge assembly 5 is filled with flushing liquid. In this case, the feed valve 27 is opened while the purge valve 29 may be either open or closed. Ink flows into the ink gun 1 from the feed line

19 and is driven out through the orifice as if an ink jet was being formed. However, because the enclosure in the charge assembly 5 is filled with flushing liquid and liquid is continually being removed from the enclosure along the suction line 25, the ink flowing out of the jet forming orifice mixes with the flushing liquid in the enclosure of the charge assembly 5 and is sucked away along the suction line 25, so that no ink jet is formed downstream of the charge assembly 5. In this case, the ink flow out through the jet forming orifice cleans it.

In the case where the charge assembly 5 does not reach the ink gun 1, the reverse flow flush arrangement is not possible. It is still possible to clean the jet forming orifice by driving ink out through it by starting the jet, but until the obstruction in the orifice is removed the ink will tend to spray onto the components downstream of the ink gun 1. Principally, this ink will strike the charge assembly 5, and it is possible subsequently to clean the hole through the charge assembly 5 by a flushing operation so as to ensure that this ink spray does not result in an ink accumulation which might interfere with the jet subsequently.

The dummy start operation has an additional advantage if it is carried out immediately before the ink jet is started for normal operation. The standard procedure for starting the ink jet if no dummy start operation has been carried out involves keeping the purge

valve 29 and the feed valve 27 both closed while the ink supply is pressurised, and then opening the feed valve 27 while keeping the purge valve 29 closed so as to provide the maximum ink pressure at the instant of starting the jet. This helps to ensure that the jet starts cleanly rather than tending to spray ink on downstream components briefly as it starts. Once the jet has been started, the purge valve 29 is opened so as to provide a strong flow of ink from the feed line 19 through the ink gun and into the purge line 29 to remove any air from inside the gun 1. However, at the moment of starting the jet any air inside the ink gun 1 will be pressurised by the supply of high pressure ink from the feed line 19, and since air is compressible this slows the transmission of ink pressure to the jet forming orifice so that the ink pressure at the orifice rises more slowly than it would if there was no air in the gun, making it more difficult to start the jet cleanly. When a dummy start is carried out, with the enclosure in the charge assembly 5 full of flushing liquid, it does not matter if there is some air in the ink gun since no jet is formed. Accordingly, a dummy start can be carried out before the jet is started, and the purge valve 29 may be opened so as to purge the ink gun of air during the dummy start procedure. After the purge valve has been closed, the feed valve 27 can then be closed to interrupt the supply of ink to the ink gun 1 briefly, while the

enclosure in the charge assembly 5 is sucked clear of flushing liquid, before starting the jet in the normal way. Since the ink gun 1 is now reliably full of ink without the presence of any air, a clean start to the ink jet is more easily obtained. In this case, it is not normally necessary to reopen the purge valve 29 after the jet has been restarted, since there is now no air in the ink gun to be purged.

The positions of the valves 27, 29, 31, 33 for various operations are set out in the following table.

	FEED VALVE 27	PURGE VALVE 29	FLUSHING VALVE 31	SUCTION VALVE 33
Flushing liquid Flow	Closed	Closed	liquid Supply	Suction
Suck Dry	Closed	Closed	Suction	Closed
Reverse Flow Flush	Closed	Open	liquid Supply	Suction
Dummy Start	Open	*	liquid Supply	Suction
Ink Jet (normal printing)	Open	Closed	Closed	Closed

* During a dummy start, the purge valve 29 may be either open or closed. If a dummy start is carried out to purge the ink gun of air before a normal starting of the ink jet, the purge valve is preferably closed at the beginning of the dummy start, then opened and then closed again before the dummy start ends.

The various operations described above can be combined, so that a typical cleaning routine conducted immediately before starting the jet (or whenever else cleaning is desired) might include initially providing a flushing liquid flow through the enclosure in the

charge assembly 5, followed either by a reverse flow flush or a dummy start (or both of these one after the other), followed by further flow of the flushing liquid through the enclosure in the charge assembly 5, followed finally by sucking the flushing liquid out of the enclosure.

Examples of construction of the ink gun 1 and the charge assembly 5 are shown in Figures 5 to 16, which are sections taken along planes which include the path of the ink jet 3.

Normally, the ink gun 1 is made at least partially of metal, which is held at a fixed potential so as to determine the potential of the ink jet. In this case, if the charge assembly 5 contacts the ink gun 1, it is important that at least a part of the charge assembly 5 is made of an electrically insulating material so as to prevent an electrical connection between the ink gun 1 and the charge electrode. This is important because electric isolation between the ink jet and the charge electrode is required for charging the ink drops. Conveniently, the electrically insulating part of the charge assembly 5 may be made from a moulded and/or machined piece of synthetic polymer. However, the material must be able to resist any corrosive or other effect of contact with the ink. Since MEK (methyl ethyl ketone) is commonly used as a solvent in ink jet printer inks, the synthetic polymer should be MEK resistant. A suitable material is PEEK (polyether ether ketone).

A construction of one example of the ink gun 1 is shown in Figure 5. Many different designs of ink gun are

known, and the illustrated construction is simply one example provided to assist understanding of the illustrated embodiments.

The ink gun 1 has an earthed metal body 35 with a tapering cavity 37 in it. The wide end of the cavity 37 is closed by a piezoelectric bimorph disc 39, which flexes in response to a drive signal provided on a wire 41. As can be seen in Figure 5, the feed line 19 and the purge line 21 both open into the cavity 37.

The narrow end of the cavity 37 is closed by a sapphire disc 43 through which a hole is drilled to provide the jet-forming orifice 45. The sapphire disc 43 is held securely in place on the body 35 by an end cap 47 which captures the disc 43 and is, for example, screwed onto the front end of the body 35. The end cap 47 has a hole 49 to allow the ink jet to pass. As can be seen in Figure 5, the hole 49 is aligned with the jet-forming orifice 45, and is of wider diameter to ensure that it does not interfere with the jet.

In use, pressurised ink from the feed line 19 flows into the cavity 37, and the ink pressure forces ink out through the orifice 45 as a jet. Vibration of the piezoelectric bimorph disc 39 under the influence of the drive signal on the wire 41 imparts pressure waves to the ink so as to control the break up of the ink jet into drops.

Many variations in ink gun design are known, particularly in respect of the shape of the cavity 37 for the ink in the body 35 of the ink gun, and the arrangement of a piezoelectric element or other means for

imparting pressure modulation to the ink jet.

The outer face of the sapphire disc 43, or other element in which the jet-forming orifice is formed, tends to accumulate spots of ink and other dirt in operation. If the sapphire disc (or other element containing the jet-forming orifice) is held by an end cap, as in the design of Figure 5, the hole in the end cap around the jet-forming orifice will tend to accumulate splashes of ink and other dirt.

Figure 6 and 7 show the front end of the ink gun 1 and the rear end of the charge assembly 5 for arrangements in which the charge assembly 5 contacts the ink gun 1. Figures 6 and 7 show a part of the synthetic polymer body 51 of the charge assembly 5, with part of the enclosure 53 around the path of the ink jet, and a passage 55 for connecting the flushing line 23 to the enclosure 53. If the charge assembly 5 contacts the ink gun 1, it is preferred that the passage 55 for the flushing liquid opens into the enclosure 53 as close to the ink gun 1 as possible. This helps to maintain a flow of flushing liquid across the part of the front face of the ink gun 1 immediately surrounding the jet-forming orifice, which is exposed to the enclosure 53. Such flow will clean the front face of the sapphire disc 43 or equivalent member and the hole in the end cap 47 more effectively than stationary flushing liquid. Placing the passage 55 close to the ink gun 1 increases the speed of flow of the flushing liquid over the jet forming orifice 45, and promotes turbulence which improves the cleaning action. This is useful particularly since the flushing

liquid is normally supplied at low flow rate, and hence a low pressure to avoid leaking (values for the pressure will depend on various factors, such as the size of the flushing line 23, but values will typically be in the range 35 to 100 kPa). Additionally, when the flushing liquid is sucked out of the enclosure 53 there is a tendency for a drop of liquid to remain in the hole 49 in the end cap 47, which would interfere with the subsequent starting of the ink jet. By placing the passage 55 as close to the end of the enclosure 53 as possible and applying suction to the passage 55, the likelihood of any drop of solvent remaining in the hole 49 is minimised.

In both Figure 6 and Figure 7, the end cap 47 of the ink gun 1 fits into a slight recess in the body 51 of the charge assembly 5. This arrangement helps to locate the parts together accurately and provide a good liquid seal between the charge assembly 5 and the ink gun 1. In Figure 6, the passage 55 is formed as a bore in the body 51, spaced slightly along the enclosure 53 from the recess which accommodates the end cap 47 of the ink gun. In Figure 7, the passage 55 is formed at the position of the recess which accommodates the end cap 47, so that the passage 55 is a bore through an outer part of the body 51 but is then a groove in the end face of the recess, so that the end cap 47 fitted into the recess provides part of the wall of the passage 55 over a part of the length of the passage 55 immediately adjacent the enclosure 53. This arrangement means that the passage 55 is already in contact with the end cap 47 at the point

where is opens into the enclosure 53. This design is particularly effective for cleaning the hole 49 in the end cap 47 and sucking the hole 49 dry of solvent at the end of a flushing operation.

Figures 8 to 16 show schematically various possible designs for the charge assembly 5. Although the design of Figure 14 is illustrated without showing any contact with an ink gun 1, it will readily be appreciated that this design could easily be implemented with such contact provided, and the designs of all of Figures 8 to 14 may be modified to accept the front of the ink gun 1 recessed into the charge assembly 5 as shown in Figures 6 and 7.

In Figure 8 the body 51 of the charge assembly 5 is provided as a block of synthetic polymer such as PEEK, and the enclosure 53 is provided as a bore through the body 51. A passage 55 for connection to the flushing line 23 is provided at one end of the body 51 and a passage 57 for connection to the suction line 23 is provided at the other end of the body 51. Between the passages 55, 57 the charge electrode 59 is provided as a plate or rod embedded in the body 51, extending alongside the enclosure 53, and separated from the enclosure 53 by a thin layer of the body 51. A metal screw 61 extends through the body 51 from its surface to contact the charge electrode 59, so as to provide an electrical contact for the charge electrode 59. Although the charge electrode 59 is shown in Figure 8 as extending only on one side of the enclosure 53, it can extend on several sides of the enclosure 53, in the form of several rods or plates or as a trough shape, or it may extend

entirely around the enclosure 53.

It is not necessary for the charge electrode 59 to be insulated from the enclosure 53, since the ink jet in normal operation will pass through the enclosure 53 without touching any part of the charge assembly 5. The thin layer of the insulating body 51 between the charge electrode 59 and the enclosure 53 increases the distance between the ink drops and the charge electrode 59, thereby reducing the capacitive coupling between them. For this reason, it is preferable to form the charge electrode 59 directly as part of the boundary of the enclosure 53, and if it is desired to insulate the charge electrode 59 from any ink splashes this is preferably done by applying an insulating coating to the relevant surface of the charge electrode 59.

Figure 9 shows an alternative arrangement which avoids the need to form the charge electrode 59 embedded in the body 51 of the charge assembly 5. In Figure 9, the charge electrode 59 bounds a part of the enclosure 53, and is provided by a metal member which is pushed into the body 51 from one end of the enclosure 53. In this arrangement the charge electrode 59 is most conveniently formed as a tube.

The construction of Figure 9 is most conveniently manufactured by forming the enclosure 53 by a bore in the body 51 having a diameter equal to the outer diameter of the tube forming the charge electrode 59, extending from one end of the body 51 to the intended position of the charge electrode 59 and continuing over the length of intended position of the charge electrode 59, and a

continuation bore of narrower diameter, for example equal to the internal diameter of the tube forming the charge electrode 59, continuing from the intended position of the charge electrode 59 to the other end of the body 51. After the body 51 has been formed, the metal tube forming the charge electrode 59 can be inserted through the larger diameter end of the enclosure 53 and pushed along the larger diameter bore until the end of the charge electrode 59 reaches the point where the wider diameter changes to the narrower diameter, at which point it is not possible to push the charge electrode 59 any further along the enclosure 53. In this way, simply by pushing the charge electrode 59 until it will not move any further, the correct positioning of the charge electrode 59 is ensured.

It can be noted in Figure 9 that one of the passages 55, 57 opens into the narrower diameter part of the bore in the body 51 forming the enclosure 53, and the tube forming the charge electrode 59 is shorter than the distance from the point where the diameter of the bore in the body 51 changes to the other of the passages 55, 57, thereby ensuring that the charge electrode 59 does not block either of the passages 55, 57. As shown in Figure 9, the passage 55 for the flushing line 23 opens into the wider diameter part of the enclosure 53, and this end of the body 51 is towards the ink gun 1, whereas the passage 57 for the suction line 25 opens into the narrower diameter part of the enclosure 53 and this end of the body 51 is towards the deflection electrodes 7, 9, but the reverse arrangement is possible.

In Figure 9, the metal screw 61 is provided as in Figure 8.

As shown in Figure 10, it is not essential for the enclosure 53 to be provided as a cylindrical bore along the whole of its length, and for example the end nearest the suction line 25 may be flared. In this case, the passage 57 for the suction line should open into the enclosure 53 at a point where its diameter is still sufficiently small (e.g. 1.1 mm) that suction from the suction line will reliably suck all of the flushing liquid passing along the enclosure 53 into the passage 57, and not allow any of the flushing liquid to dribble out through the flared end of the enclosure 53. Since the flared end of the enclosure 53 will not be filled with flushing liquid during a flushing operation, the flushing operation will not clean this part of the enclosure 53. However, the widening diameter of this part of the enclosure 53 means that cleaning of it is less important. In general, it is not preferred for the enclosure 53 to extend substantially beyond the passage 57 for the suction line 25.

Figure 11 shows an alternative construction in which the charge assembly 5 is provided by a tube 63 of an insulating material which extends through a slightly larger diameter tube of metal forming the charge electrode 59. The insulator tube 63 is longer than the charge electrode 59 to allow side tubes 65, 67 to be provided for connection to the flushing line 23 and the suction line 25.

In order to avoid the separation of the charge

electrode 59 from the ink drops by the thickness of the insulating tube 63, the design of Figure 11 may be modified as shown in Figure 12. In Figure 12, the main body of the charge assembly 5 is provided by the cylindrical charge electrode 59 itself, and short insulating cylindrical extensions 69, 71 are cemented to each end of the charge electrode 59 to carry the side tubes 65, 67.

As a further modification, the insulating extensions 69, 71 can be omitted and the side tubes 65, 67 may be formed from the metal of the charge electrode 59. However, in this design there is an insulating piece 72 between the electrically conductive charge assembly 5 and the ink gun 1.

At present, the designs of Figures 11, 12 and 13 are not preferred, because the use of side tubes 65, 67 in place of passages 55, 57 through a solid body 51 makes the design more difficult to manufacture cheaply, robustly and reliably.

In the constructions for the charge assembly 5 discussed so far, there has been one flushing line 23 and one suction line 25. However, additional flushing or suction lines can be used. Figure 14 shows an arrangement having one passage 55 for connection to the flushing line 23, and two passages 57a, 57b for connection to respect suction lines 25 (or connection to respective branches which join to form a common suction line 25). The passage 55 for the flushing line 23 is provided near the mid-point of the enclosure 53 and the passages 57a, 57b for the suction lines are provided one

at each end of the enclosure 53.

This arrangement is particularly useful for designs where the charge assembly 5 does not contact the ink gun 1, so that both ends of the enclosure 53 are open. By moving the flushing liquid supply away from one of the open ends of the enclosure 53, and providing suction at both ends, this design avoids the tendency for flushing liquid to leak out of the end of the enclosure 53 adjacent the passage 55 for flushing liquid if this end of the enclosure 53 is open. The pressure of the flushing liquid supply and the strength of the suction applied to the passages 55, 57a, 57b relative to atmospheric pressure should be chosen so as to ensure that flushing liquid flows reliably from the passage 55 in both directions along the enclosure 53 so as to flush the whole length.

Although the advantages of the design of Figure 14 are particularly relevant to arrangements in which the charge assembly 5 does not contact the ink gun 1, this design can also be used in arrangements where the charge assembly does contact the ink gun 1.

Figure 15 shows an arrangement in which the charge assembly 5 is provided by two pieces. A metal tube provides the charge electrode 59, and carries a metal side tube 67 for connection to the suction line 25. An insulating tube 73 spaces the metal charge electrode tube 59 from the end cap 47 of the ink gun 1, and includes a passage 55 for communication with the flushing line 23.

As will be appreciated by those skilled in the art, a very wide variety of designs for the charge assembly

5 is possible.

Figure 16 illustrates a design which is presently preferred, in more detail than is shown in Figures 8 to 15. The basic construction of the charge assembly of Figure 16 is similar to that shown in Figure 9.

In Figure 16 the main body 51 of the charge assembly 5 is made of PEEK. The body is intended to contact the ink gun 1, and has a recess 75, about 6 mm wide and 4 mm deep for accommodating the end cap 47 of the ink gun 1. The passage 55 for connection to the flushing line 23 and the passage 57 for connection to the suction line 25 are each 1 mm in diameter. As described above with reference to Figure 7, the passage 55 for the flushing liquid opens into the recess 75, and the centre line of the passage 55 is in line with the end surface of the recess 75. A screw threaded cavity 75, 79 is provided at the end of each of the passages 55, 57, for receiving screw threaded connectors fitted to the end of the flushing line 23 and the suction line 25.

To form the enclosure 53 and accommodate the tubular charge electrode 59, a bore 1.5 mm in diameter extends along the path of the ink jet from the recess 75 and a bore 1.1 mm in diameter extends along the path of the ink jet from the other end of the body 51. The tubular charge electrode 59 has an outer diameter of 1.5 mm and an inner diameter 1.1 mm, and is about 6 mm long. It is positioned in the wider diameter bore pressed against the annular step formed where the two bores meet. A threaded hole 81 is provided for the screw 61 (not shown in Figure 16) which provides electrical contact to the charge

electrode 59 and also helps to hold it in place. In principle, the narrower diameter bore could be made from the recess 75 and the wider diameter bore from the other end of the body 51. However, the arrangement illustrated in Figure 16 is preferred because this has the result that the open end of the enclosure 53, away from the recess 75, is formed by the narrower diameter bore, reducing the size of the opening at this end and thereby minimising the tendency of the flushing liquid to dribble out of the opening during the flushing operation.

A space 83, of enlarged diameter compared with the remainder of the enclosure 53, is provided where the enclosure 53 opens into the recess 75. As shown in Figure 16, this space is formed by a short cylindrical portion extending from the recess 75 followed by a tapering (countersink) portion, but this precise shape is not necessary. This space 83 is advantageous, as it provides a small volume for holding any spray which may be produced at the jet-forming orifice of the ink gun at the moment of starting the ink jet. Because such spray can be accommodated in the volume provided by the space 83, the probability that any such spray will block the enclosure 53 is substantially reduced. This is advantageous, since any such blockage of the enclosure 53 will obstruct the jet, and therefore will prevent the jet from starting properly. It is preferred to provide some such space 83 in any design of the charge assembly 5 which contacts the ink gun 1 so that the enclosure 53 encloses the jet-forming orifice.

The passage 57 for connection to the suction line

25 opens into the enclosure 53 less than 1 mm from its end. In order to accommodate the diameter of the screw threaded cavity 79, the part of the body 51 around the screw threaded cavity 79 extends beyond the end of the enclosure 53. In contrast to the arrangement of Figure 10, this need to extend the length of one part of the body 51 does not lead to any extension of the enclosure 53.

As a comparative test, a Midi print head as commercially available from Linx Printing Technologies PLC was tested by repeated starts of the ink jet without any manual cleaning, until the jet failed owing to accumulation of ink on the charge electrode, at which point it was cleaned manually and the testing resumed. The number of jet starts obtained, before cleaning was required, varied from test to test, but manual cleaning always became necessary in the end, normally after less than a hundred jet starts. This print head was then modified to replace the charge electrode with a charge assembly similar to the one illustrated in Figure 16, and the control electronics were set to perform an automatic cleaning operation to flush the enclosure 53 and the jet-forming orifice 45 in the sapphire disc 43 before each jet start. The modified print head, having the charge assembly and automatic cleaning performed a thousand jet starts without any manual cleaning of the charge assembly having been required.

In addition to the improvement in performance provided by flushing the enclosure 53 of the charge assembly 5 before each time the ink jet is started, the

tendency of the ink jet to fail due to accumulation of the ink on the charge electrode depends on the internal diameter of the charge electrode. If the internal diameter of the charge electrode is reduced from the 1.1 mm used in Figure 16, this would increase the charge captured on the ink drops as the coupling between the charge electrode and the ink drops would be improved. This would permit a lower voltage on the charge electrode 59 or a lower deflection voltage on the deflection plates 7, 9, for the same angle of deflection. However the tendency of the ink jet to strike the internal surface of the charge assembly would be increased and the tendency of ink accumulation on the charge electrode 59 to interfere with the ink jet would also increase. One way of reducing this problem would be to coat the inner surface of the charge electrode 59 with a thin hydrophillic layer, so that any drops of ink touching the charge electrode would tend to spread out thinly over the charge electrode surface rather than forming fatter localised drops.

The illustrated embodiments all relate to a printer with only a single ink jet. However, the invention can also be applied to printers having multiple jets of ink. For example, a type of printer is known in which an array of ink jets are formed in a row, each jet being associated with a respective charge electrode, and a common deflection electrode arrangement provides a deflection field for deflecting the drops of a plurality of the jets. Where there are a plurality of ink jets, a respective enclosure, with flushing liquid supply and

suction lines, may be provided for each jet. This may be done by providing a separate respective charge assembly for each jet, or by providing separate enclosures in single assembly which is common to a plurality of jets. Where a single assembly is common to a plurality of jets, it is also possible in principle to provide a single flushable enclosure for a plurality of jets, but in practice the cross section of such an enclosure becomes so large that it is difficult to provide a flushing flow and difficult to prevent the flushing liquid from dribbling out of the open end or ends of the enclosure.

The various embodiments described above have been provided by way of example, and are not intended to limit the scope of the present invention. Various further and alternative designs will be apparent to those skilled in the art, and it will also be apparent to those skilled in the art that selected features from one illustrated design can be combined with selected features from other illustrated designs in a wide variety of ways. The particular combinations of features illustrated have been chosen only to show examples of the varieties of designs which are possible and are not intended to imply that one feature must be present with another feature simply because they appear in the same illustrated example.

CLAIMS

1. An ink jet printer comprising:

an ink gun for ejecting, through an orifice, a jet of ink which separates into ink drops;

a charge electrode for inducing an electric charge in the ink jet as it separates into ink drops so as to capture electric charge on the ink drops; and

a deflection electrode arrangement for creating an electric field to deflect the charged ink drops by interaction with the electric charge on the ink drops,

the ink jet printer having enclosure means enclosing a portion of the path of the ink jet at the location of the charge electrode, liquid supply means to supply liquid to the portion of the path of the ink jet enclosed by the enclosure means for flushing it, and suction means for removing from the enclosed portion of the ink path the liquid supplied by the liquid supply means,

and the enclosure means has an exit opening through which the ink path leaves the enclosure means, a first conduit, communicating with a first position on the enclosed portion of the ink path, for receiving liquid from the liquid supply means, and a second conduit, communicating with a second position on the enclosed portion of the ink path, for passing liquid from the enclosed portion of the ink path to the liquid suction means,

the second position being between the exit opening and the first position and the minimum diameter of the space enclosed by the enclosure means between the second position and the exit opening being not more than 2 mm,

and either (i) the enclosure means has an entrance opening, through which the ink path enters the enclosure means, and a third conduit, communicating with a third position on the enclosed portion of the ink path, for passing liquid from the enclosed portion of the ink path to the suction means, the third position being between the entrance opening and the first position and the minimum diameter of the space enclosed by the enclosure means between the third position and the entrance opening being not more than 2 mm, or (ii) the enclosure means encloses the said orifice of the ink gun.

2. A printer according to claim 1 in which the suction means applies a static suction of at least 80 kPa below atmospheric pressure.

3. A printer according to claim 1 or claim 2 comprising means to apply suction to the first conduit.

4. A print head for an ink jet printer, the print head comprising:

an ink gun for ejecting, through an orifice, a jet of ink which separates into ink drops;

a charge electrode for inducing an electric charge in the ink jet as it separates into ink drops so as to capture electric charge on the ink drops; and

a deflection electrode arrangement for creating an electric field to deflect the charged ink drops by interaction with the electric charge on the ink drops,

the print head having enclosure means enclosing a portion of the path of the ink jet at the location of the charge electrode, fittings for connection to liquid supply means to supply liquid to the portion of the path of the ink jet enclosed by the enclosure means for flushing it, and fittings for connection to suction means for removing from the enclosed portion of the ink path the liquid supplied by the liquid supply means,

and the enclosure means has an exit opening through which the ink path leaves the enclosure means, a first conduit, communicating with a first position on the enclosed portion of the ink path, for receiving liquid from the fitting for connection to the liquid supply means, and a second conduit, communicating with a second position on the enclosed portion of the ink path, for passing liquid from the enclosed portion of the ink path to the fitting for connection to the suction means,

the second position being between the exit opening and the first position and the minimum diameter of the space enclosed by the enclosure means between the second position and the exit opening being not more than 2 mm,

and either (i) the enclosure means has an entrance opening, through which the ink path enters the enclosure means, and a third conduit, communicating with a third

position on the enclosed portion of the ink path, for passing liquid from the enclosed portion of the ink path to the fitting for the suction means, the third position being between the entrance opening and the first position and the minimum diameter of the space enclosed by the enclosure means between the third position and the entrance opening being not more than 2 mm, or (ii) the enclosure means encloses the said orifice of the ink gun.

5. An ink jet printer according to any one of claims 1 to 3 or a print head according to claim 4 in which the said minimum diameter does not exceed 1.5 mm.

6. An ink jet printer according to any one of claims 1 to 3 or a print head according to claim 4 in which the said minimum diameter is in the range of 1.0 to 1.2 mm.

7. An ink jet printer according to any one of claims 1 to 3, 5 and 6 or a print head according to any one of claims 4 to 6 in which the enclosure means comprises the charge electrode.

8. An ink jet printer or a print head according to claim 7 in which the enclosure means comprises an insulating body which separates the charge electrode from the enclosed portion of the ink path.

9. An ink jet printer or a print head according to claim 8 in which the charge electrode is embedded in the insulating body.

10. A printer or a print head according to claim 7 in which a surface of the charge electrode provides part or all of the surface of the enclosure means which encloses the said portion of the path of the ink jet.

11. A printer or a print head according to claim 10 in which the surface of the charge electrode has a hydrophillic coating.

12. A printer according to any one of claims 1 to 3 and 5 to 11 or a print head according to any one of claims 4 to 11 in which the enclosure means encloses the said orifice of the ink gun.

13. A printer or a print head according to claim 12 in which the enclosure means has a conduit for conveying liquid, supplied by the liquid supply means, to the enclosed portion of the ink path or for conveying liquid, to be removed by the suction means, from the enclosed portion of the ink path, which conduit opens into the enclosed portion of the ink path at the said orifice of the ink gun.

14. A printer or a print head according to claim 13 in which the said conduit is bounded, over at least a part of its length, by the surface of the ink gun.

15. A printer according to any one of claims 1 to 3 and 5 to 14 or a print head according to any one of claims 4 to 14 in which the enclosure means is made, at least in part, from an electrically insulating material which is resistant to methyl ethyl ketone.

16. An ink jet printer according to any one of claims 1 to 3 and 5 to 15 comprising means to take liquid from a liquid source and dilute the ink with it, and means to take liquid from the same liquid source and provide it to the liquid supply means.

17. An assembly, for use in a printer according to any one of claims 1 to 3 and 5 to 16, comprising the enclosure means and the charge electrode.

18. An assembly for use in a printer according to any one of claims 1 to 3 and 5 to 16 or for use in a print head according to any one of claims 4 to 15, comprising the charge electrode and the enclosure means, the enclosure means having fittings for connection to the liquid supply means and the suction means.

19. An assembly, for use in a print head according to any one of claims 4 to 15, comprising the enclosure means and the charge electrode.

20. A method of operating an ink jet printer according to any one of claims 1 to 3 and 5 to 16, comprising supplying liquid to a first location on the enclosed portion of the ink path and simultaneously removing liquid from a second location on the enclosed portion of the ink path, so as to cause liquid to flow from the first location to the second location, and subsequently clearing the enclosed portion of the ink path of liquid.

21. A method according to claim 20 in which the

step of clearing the enclosed portion of the ink path includes clearing liquid from at least a portion adjacent the ink path of every conduit in the enclosure means which communicates with the ink path.

22. A method of operating an ink jet printer according to any one of claims 12 to 16 comprising flooding the enclosed portion of the ink path with liquid and applying suction to the interior of the ink gun to suck liquid from the enclosed portion of the ink path into the ink gun through the said orifice.

23. A method of operating an ink jet printer according to any one of claims 12 to 16 comprising flooding the enclosed portion of the ink path with liquid, ejecting a liquid (e.g. ink) from the ink gun through the orifice into the flooded portion of the ink path, ceasing to eject liquid from the ink gun through the orifice, and subsequently clearing the enclosed portion of the ink path of liquid.

24. A method according to claim 23 which comprises applying suction to the interior of the ink gun during the step of ejecting a liquid from the ink gun.

25. A method according to any one of claims 20 to 24 in which the ink is diluted with the same liquid as is supplied to the enclosed portion of the ink path by the liquid supply means.

FIG.1

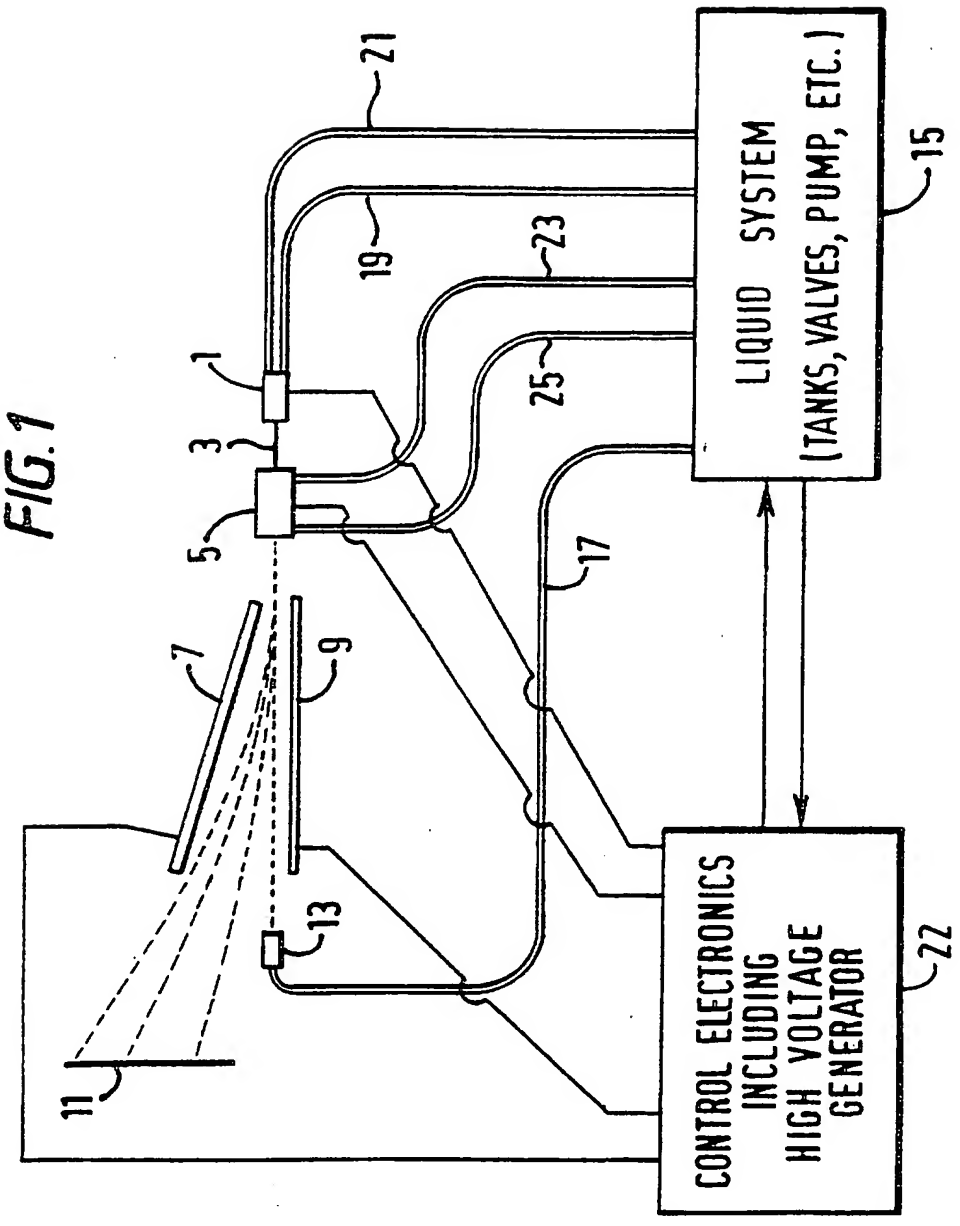

21
19
23
25
1
3
5
17
15
LIQUID SYSTEM
(TANKS, VALVES, PUMP, ETC.)
7
9
13
11
CONTROL ELECTRONICS
INCLUDING
HIGH VOLTAGE
GENERATOR
22

FIG. 2

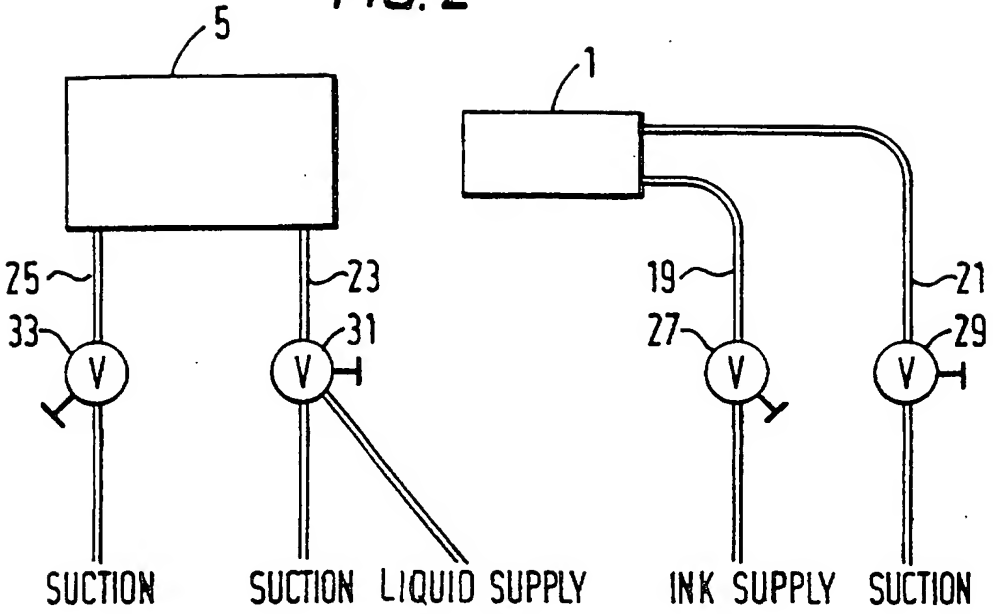

5
1
25
23
19
21
33
31
27
29
V
SUCTION
SUCTION
LIQUID SUPPLY
INK SUPPLY
SUCTION

FIG. 4

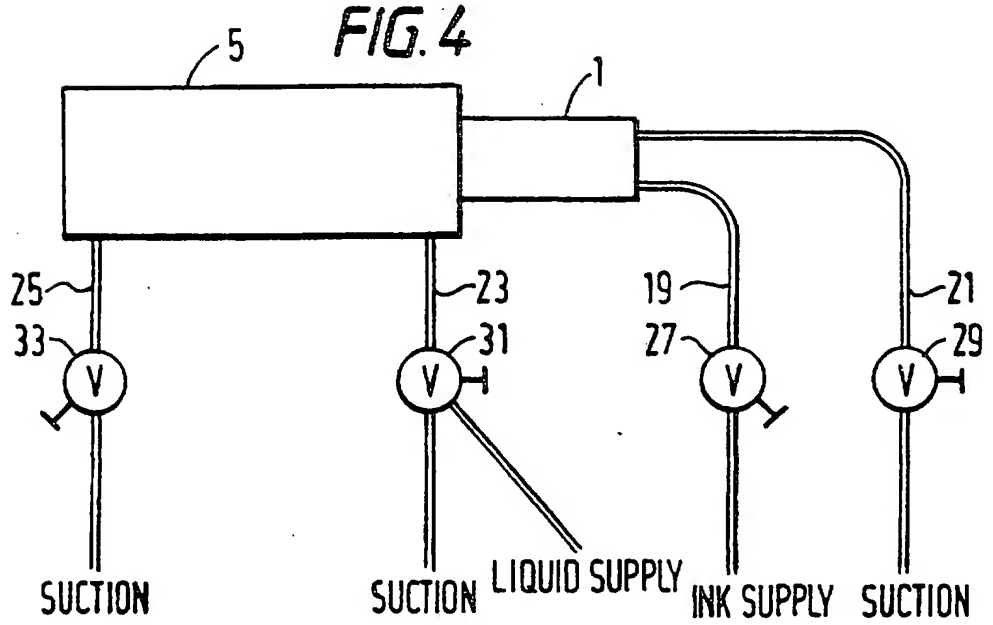

5
1
25
23
19
21
33
31
27
29
V
SUCTION
SUCTION
LIQUID SUPPLY
INK SUPPLY
SUCTION

FIG.3

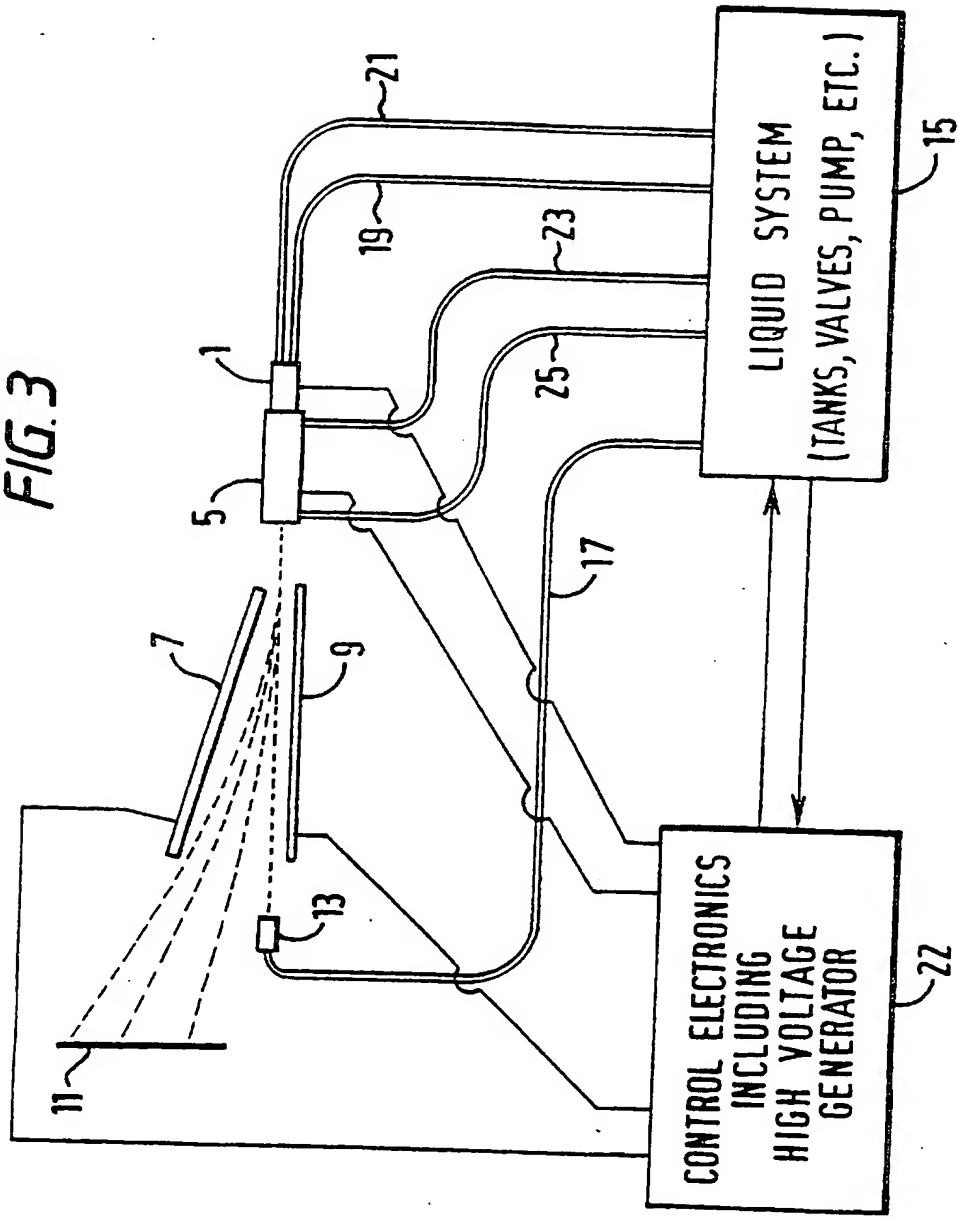

LIQUID SYSTEM
(TANKS, VALVES, PUMP, ETC.)
15
CONTROL ELECTRONICS
INCLUDING
HIGH VOLTAGE
GENERATOR
22
21
19
23
25
1
5
17
7
9
13
11

FIG. 5

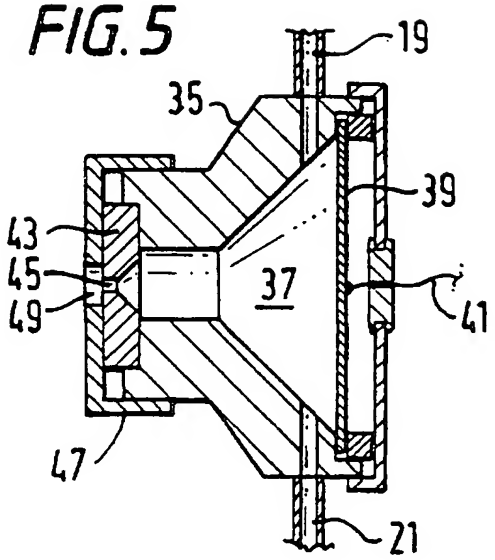


FIG. 6

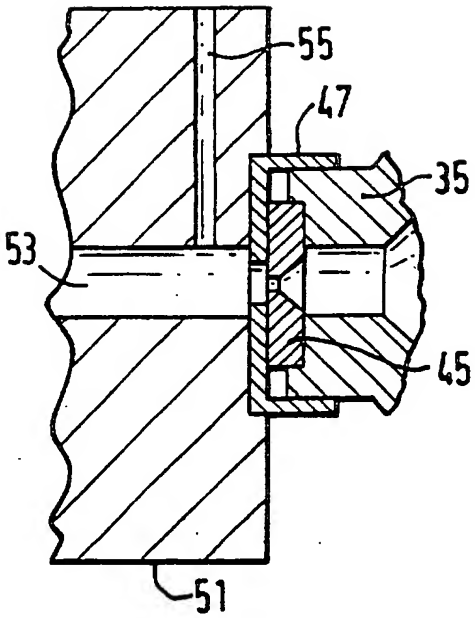
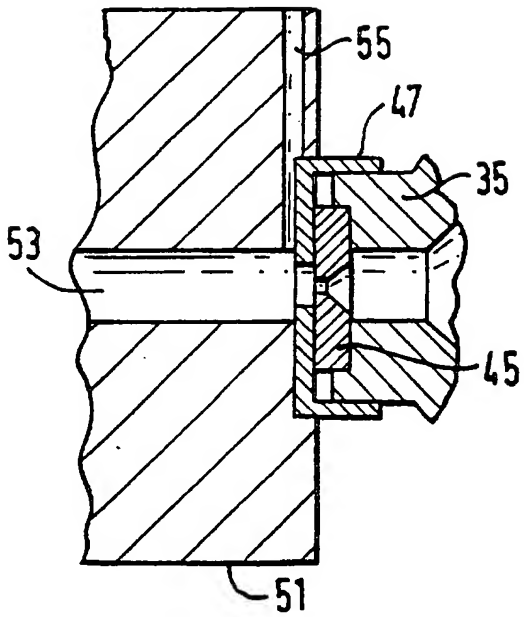


FIG. 7



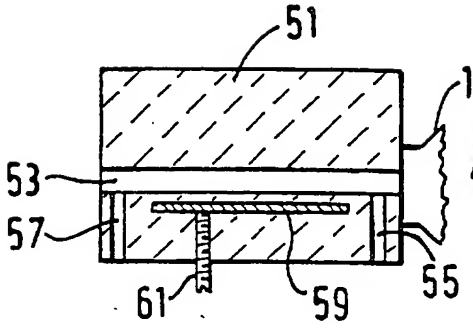


FIG. 8

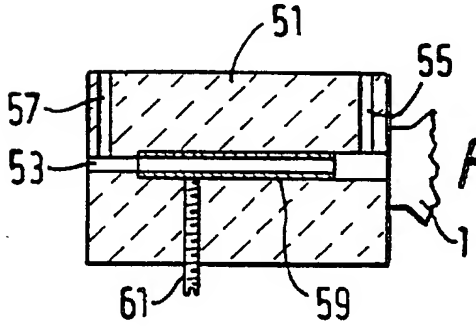


FIG. 9

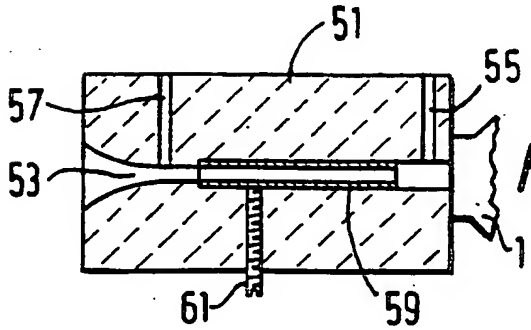


FIG. 10

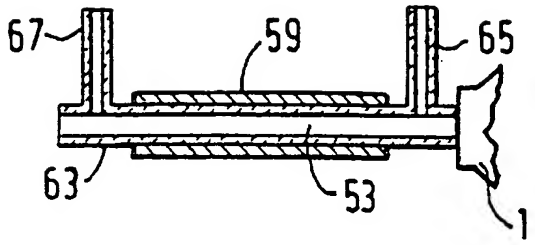


FIG. 11

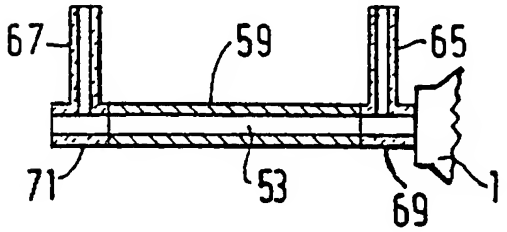


FIG. 12

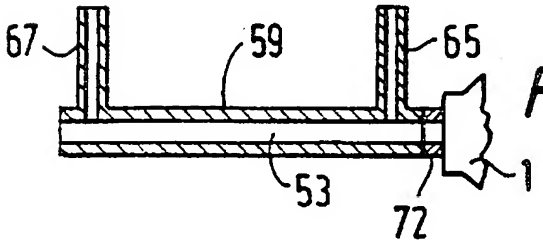


FIG. 13

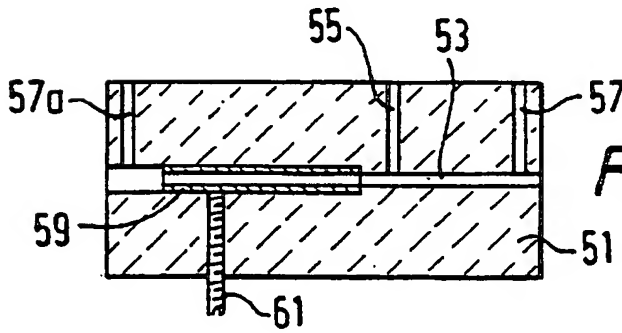


FIG. 14

FIG. 15

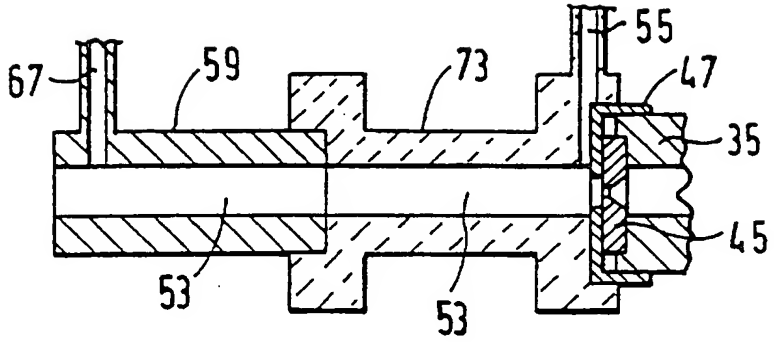
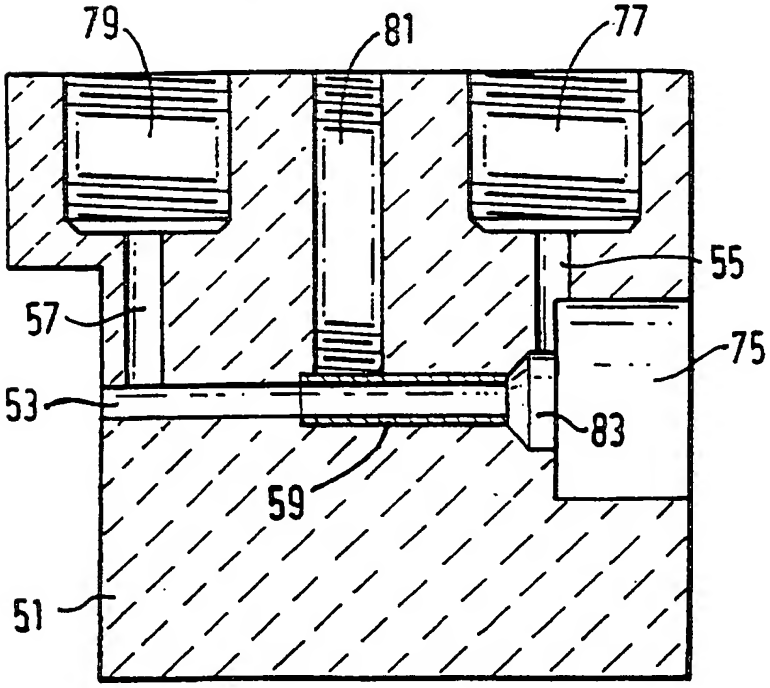


FIG. 16



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/02107

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B41J2/165

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 242 (M-1259), 3 June 1992 & JP 04 053753 A (TOPPAN PRINTING CO LTD), 21 February 1992, cited in the application see abstract ---	1-8, 20-25
A	PATENT ABSTRACTS OF JAPAN vol. 004, no. 108 (M-024), 5 August 1980 & JP 55 067484 A (RICOH CO LTD), 21 May 1980, see abstract ---	1,20
A	EP 0 424 008 A (LINX PRINTING TECHNOLOGIES LIMITED) 24 April 1991 cited in the application see the whole document --- -/--	1-8, 20-25

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
3 December 1997	11/12/1997

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Meulemans, J-P

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/02107

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 006, no. 089 (M-132), 27 May 1982 & JP 57 027757 A (RICOH CO LTD), 15 February 1982, see abstract	1
A	ANONYMOUS: "Selective Ink-Jet-Assembly Cleaning. June 1980." IBM TECHNICAL DISCLOSURE BULLETIN, vol. 23, no. 1, June 1980, NEW YORK, US, pages 93-95, XP002031477 cited in the application	1-8, 20-25

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 97/02107

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		AT 123706 T	15-06-95
		DE 69020092 D	20-07-95
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		ES 2075164 T	01-10-95
		JP 3193460 A	23-08-91
		US 5126752 A	30-06-92